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Environmental Enrichment: Behavioral Response of Rhesus to Puzzle Feeders

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DIVISION OF OCULAR HAZARDS

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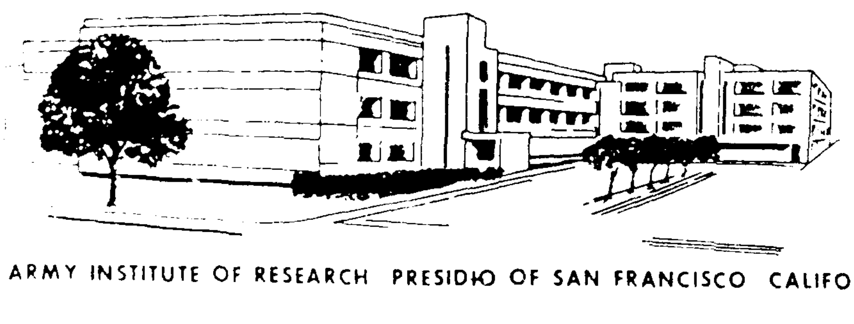

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AMENDMENTS TO DEPARTMENT OF AGRICULTURE STANDARDS REGULATING THE PHYSICAL ENVIRONMENT OF LABORATORY PRIMATES HAVE SERVED AS AN IMPETUS FOR RESEARCH INVOLVING ENVIRONMENTAL ENRICHMENT. TOOLS AND TECHNIQUES ARE BEING DEVELOPED WHICH ADDRESS THE MOST CONTROVERSIAL ASPECT OF THE AMENDED STANDARDS, I.E. THE REQUIREMENT THAT THE PHYSICAL ENVIRONMENT BE ADEQUATE TO PROMOTE THE PSYCHOLOGICAL WELL-BEING OF LABORATORY PRIMATES. THE PURPOSE OF THIS STUDY WAS TO ASSESS THE UTILITY OF ONE TECHNIQUE WHICH PROVIDES A MONKEY WITH THE OPPORTUNITY TO PERFORM A PREFERRED, MEANINGFUL TASK. THE CAGE OF TWO ADULT RHESUS MONKEYS WERE EQUIPPED WITH A FEEDING DEVICE IN THE FORM OF A CHANGEABLE MAZE. THE ANIMALS RECEIVED THEIR NORMAL DAILY DIET OF MONKEY CHOW THROUGH THE MAZE. THEY NEEDED TO USE THEIR FINGERS TO MANIPULATE THE FOOD WITHIN THE MAZE UNTIL THE BISCUITS WERE MOVED TO THE FINAL LEVEL WHERE THEY COULD BE RETRIEVED. (CONTINUED BACK)

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ABSTRACT

Amendments to Department of Agriculture standards regulating the physical environment of laboratory primates have served as an impetus for research involving environmental enrichment. Tools and techniques are being developed to address the most controversial aspect of the amended standards, i.e. the requirement that the physical environment be adequate to promote the psychological well-being of laboratory primates. The purpose of this study was to assess the utility of one technique which provides a monkey with the opportunity to perform a preferred, meaningful task. The cages of two adult rhesus monkeys were equipped with a changeable maze through which the animals received their normal daily diet of monkey chow. They needed to use their fingers to manipulate the food within the maze until the biscuits were moved to the final level where they could be retrieved. Evaluation of the responses of the two rhesus monkeys revealed that the variable maze patterns consistently present the animals with a stimulus for activity. The feeder provides both environmental complexity and the opportunity to engage in behaviors which simulate, to some extent, foraging activities seen in feeding behavior in natural habitats.

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INTRODUCTION

The 1985 amendments to the Animal Welfare Act required the United States Department of Agriculture to develop standards for a physical environment adequate to promote the psychological well-being of laboratory primates. With the adoption of these requirements came the impetus for considerable research efforts to develop the criteria and techniques to provide for enrichment.

Principal areas of investigation have centered on the complex issues of housing and development of appropriate behavioral tasks and equipment. In the arena of caging, there is considerable controversy over the physical dimensions required by the numerous species of captive nonhuman primates. The important relationship between the amount of living space and the quality of that space remains a very volatile issue. While perhaps not so emotional a question as cage requirements, there are also many opinions on how best to provide living conditions which meet the intent of the amended Animal Welfare Act.

Line and Houghton (1), among others, suggested that providing the opportunity for activities similar to behavior in the wild is one way to enhance the psychological well-being of laboratory primates. Activities of monkeys in their natural habitats revolve primarily around feeding-related behaviors, resting, and social interaction. Appropriate means for providing social interaction are intimately tied to the types of cage environments and the relative merits of individual and group housing, and are outside the scope of this paper.

In his review, Line (2) reported that environmental complexity is a major factor in successfully enriching a primate's living conditions. He also pointed out the necessity of matching species specific natural behavior with development of apparatus or techniques applied to caged monkeys. Techniques employing devices or objects to foster environmental enrichment by prompting behaviors which simulate naturally occurring behaviors cluster predominantly into two categories: simulated foraging activity, and "cage toys" which encourage manipulation of non-food-related objects. Items suspended from the cage ceiling, such as hard nylon balls (3), swings and nylon ropes (4) have produced equivocal results. Jerome and Szostak (5) provided paired-housed baboons with various types of "play" and "foraging" devices. While the play objects (balls, chains and ropes) elicited activity, the foraging devices such as raisin boards, were used more consistently. In our laboratory, we have observed that play objects are often ignored once the novelty diminishes. Similar findings have been reported by other investigators (1,3,4). Bryant et al concluded that maintaining a monkey's interest in the home cage, especially when social interaction is limited or unavailable, may require enrichment of the environment in a way that is "biologically meaningful to the monkey" (4).

In attempting to provide biologically meaningful activity, we felt that environmental enrichment may best be served by providing monkeys a combination of foraging and manipulative activities. All who have worked behaviorally with monkeys recognize their initial curiosity and interest in touching new objects. We hoped that such interest would be extended if feeding behavior was made an integral component of a manipulative device. The Puzzle Feeder (Primate Products, Woodside, CA) appears to meet that requirement by combining a simulated foraging activity with the opportunity to move and control an object in the cage environment.

METHODS

Subjects:

Two adult male rhesus monkeys (*Macaca mulatta*) served as the subjects for this study.

Apparatus:

The Puzzle Feeder shown in Figure 1 is a rectangular clear plexiglass box 12" high X 6" wide X 2" deep. It is easily attached to the cage by plastic tie-wraps. The feeder can be left on the cage during cage washing, or can be quickly removed by cutting the tie-wraps. The five upper levels of the feeder are made from individual horizontal or vertical pieces of red or blue plexiglass which can be arranged to form hundreds of maze patterns. The uppermost level was loaded with 10 unshelled peanuts. Figures 1 and 2 show the task facing the two adult male rhesus monkeys. Moving the peanuts through the maze required inserting a finger through openings into the puzzle and pushing the food along a level until it dropped to the next lower row. When the peanut had been moved through all the levels, it dropped to the bottom of the maze where it could be retrieved through a larger oval opening. Only one opening is available for removing the food, as the remaining finger holes are only large enough to insert one or two fingers.

FIGURE 1. *Puzzle Feeder attached to the front of the cage door. Rhesus N-231 can be seen pushing a peanut off the upper row. Holes on the outside of the feeder allow the handler to move the peanuts if the monkey requires assistance. No help was provided during the present study.*

FIGURE 2. *The task presented to the monkeys requires inserting a finger into successive finger holes to push the food through the maze. Cage design can pose problems if the spacing of the bars or grids prevents access to necessary openings. The configuration of our cages made retrieval of the food from the bottom opening somewhat difficult because two vertical bars partially covered the hole. Peanuts, however, were easily removed. Single-size monkey biscuits (Purina Mills, St. Louis, MO) have also been used, with removal being somewhat more difficult.*

Procedure:

The Puzzle Feeder was placed on the front door of the monkeys' home cage, above the opening through which the monkeys gained access to their regular feeding of monkey biscuits. The peanuts were a supplement to the normal feeding, with all testing occurring after the one morning feeding. The room contained eight single bank cages facing each other, four on each side. No attempt was made to control the possible distractions caused by the activity or vocalizations of the other monkeys in the room. The time taken to retrieve and eat all ten peanuts was measured by an observer in the room.

Although it is possible to arrange many maze patterns, we limited the complexity of the patterns in this study to increasing the number of horizontal levels through which the peanuts had to be pushed. The initial, and simplest, pattern required moving the peanuts across the uppermost row of the blue plexiglass pieces where the peanuts had been loaded. An opening in all the rows at one end allowed the peanut to drop to the bottom level where it had to be moved to the oval opening for removal. The level of difficulty was increased by closing off the blank positions leading to the lowest level so the peanut could only drop to the next lower row. This procedure added levels that had to be traversed, to a maximum of five rows. Adding new levels required the monkeys to move the peanuts in different directions across the full width of each subsequent row. Each particular maze level was maintained until the total time for completion within a session remained nominally within 1 minute over three consecutive days.

RESULTS

Data for the last three days at each maze level were analyzed using the BMDP 3V mixed model analysis of variance (BMDP Statistical Software Inc, Los Angeles, CA) to perform a Chi-Square analysis. Individual differences exist in the amount of time needed to complete the maze at each level of difficulty (Chi-Square = 9.741, DF = 1, $p = .002$). The number of days needed to reach asymptotic levels also differed between monkeys. While individual differences do exist, it is evident in Figures 3 and 4 that the learning curves for each monkey show quite similar trends. The transition between levels of difficulty in the maze are usually marked by large increases in the total time taken to consume the 10 peanuts. Though numerous outbreaks of vocalizations from the remaining 6 monkeys in the room created distractions while the two test monkeys were engaged with the Puzzle Feeder, the subjects never stopped working the maze to respond to or join the vocal activity. As the complexity of the task was increased, each monkey required significantly more time to finish the task. The maximum duration following the transition to the next level did not, however, consistently occur on the first day of increased difficulty. When maze complexity was increased generalization was delayed, with maximum feeding times occurring as late as 7 days following a transition. As completion times became stable they remained elevated above those at the previous level. Significant differences (Chi-Square = 70.121, DF = 5, $p < .001$) between final times at each maze level reflect the added difficulty faced by the monkeys at successive levels.

On a few occasions the time for monkey N-231 to finish level 4 was in excess of 30 minutes. Even though

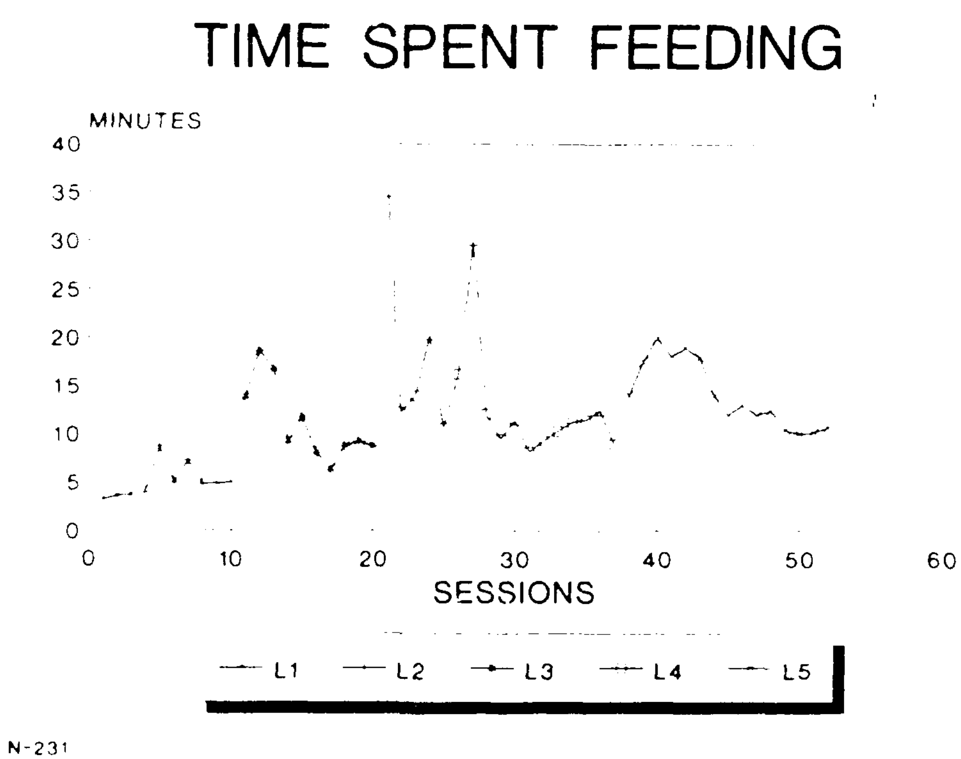

FIGURE 3. *Puzzle Feeder data for Rhesus N-231. The total time in minutes to retrieve and consume 10 whole peanuts in the shell is displayed across sessions. The 5 levels of maze complexity are represented by L1 through L5.*

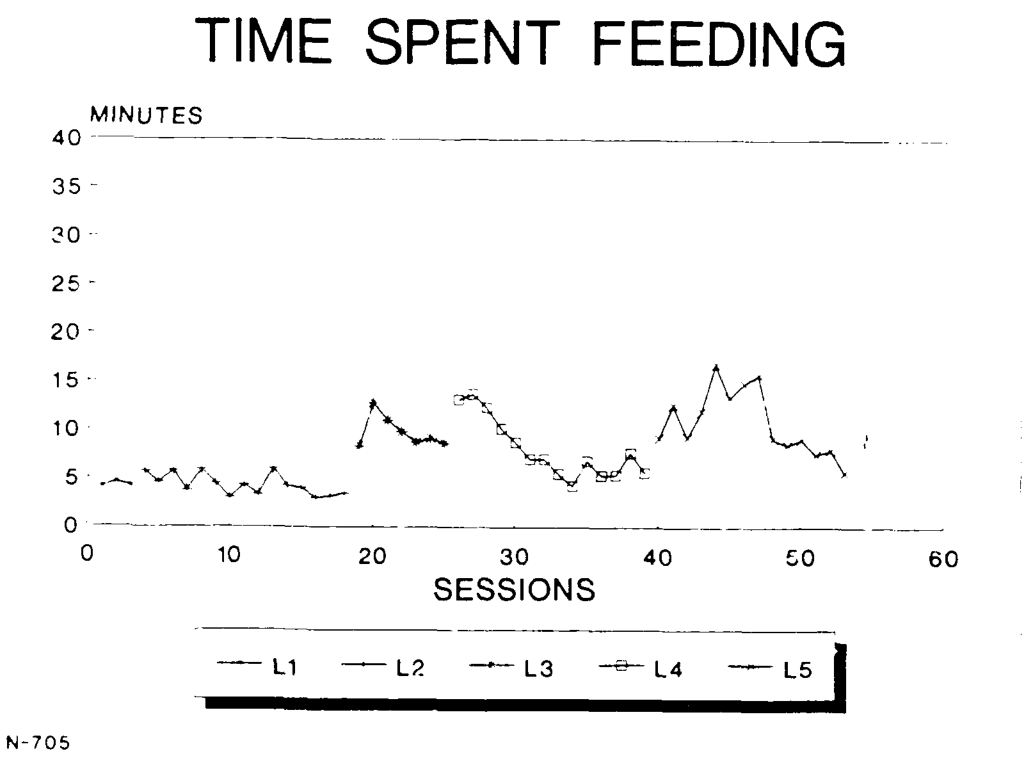

FIGURE 4. *Puzzle Feeder data for Rhesus N-705. Trends in the generalization curves for successive levels of difficulty are similar to those seen in Figure 3. Individual differences are evident in the final times, with N-705 showing shorter durations. The success of N-705 resulted from his tendency to propel the peanuts across the rows with strong pushes, not pushing each peanut hole to hole as preferred by N-231.*

average completion time was in the 10 to 15 minute range, the monkey persevered. While watching the monkeys work the maze, one could readily see that there was almost total absorption in the task, thus the longest completion times were not a result of the monkey ignoring the maze for periods of time.

DISCUSSION

One of the generally agreed upon requirements for any behavioral engineering apparatus is that it provide an opportunity for the animal to perform a preferred, biologically meaningful task. If, as Line (1) suggests, one method for enrichment is to use devices that contribute to environmental complexity and stimulate activity, then the results of the present study suggest that the Puzzle Feeder may be an appropriate candidate for improving the psychological well-being of laboratory primates. Evaluation of the rhesus monkey responses revealed that the variable maze patterns provided a stimulus for activity. The Feeder provided both environmental complexity and the opportunity to engage in behaviors which simulate, to some extent, foraging activities seen in feeding behavior in natural habitats.

While purely manipulative devices and objects may draw the monkey's attention initially, these types of techniques have usually failed to maintain that attention for more than relatively short periods of time (2,3,4). Including food into the environmental enrichment regimen, however, may provide strong motivation even if the food provided is not the animal's primary diet. The strength of such a stimulus can be seen in the report of an electromechanical cage device combining a radio and food dispenser (6) where some monkeys responded to the feeder more than 2000 times per day. A growing number of studies are reporting the preference of primates to engage in "work" for their food even when food is provided if the experimental dispensing devices are not used (2,7).

In our laboratory, we have seen a similar "work ethic" in monkeys involved in behavioral research. Some of our animals "prefer" to work for liquid reinforcements even when supplemented to a consistent level in their home cage. In this vein, we should not overlook enriching aspects of a monkey's participation in behavioral experiments employing positive reinforcement. By using proper precautions and consideration the monkeys can be more than merely subjects of experimentation, and can become willing and active participants. Activities provided by such research contain many of the positive factors sought in environmental enrichment programs. The monkeys are presented tasks which require attention and consistent response, and are provided opportunities to manipulate their environment by directly controlling the delivery of food and/or liquids.

CONCLUSIONS

In summary, we are gratified to see the interest the rhesus show in the Puzzle Feeder. We feel that the combination of tactile manipulation and foraging behavior serves as a valuable component of any program aimed at improving living conditions for laboratory primates. While the total durations spent using the feeder were relatively short, this study has not attempted to define limits by exploring the maximum level of difficulty tolerated by the monkeys. The two monkeys involved in this study are currently using the Puzzle Feeder as a primary feeding device. Using standard single portion monkey biscuits, feeding times have been extended from approximately 10 minutes without the Puzzle Feeder to durations of 20-30 minutes when presented with the relatively low difficulty of Level 5. If the monkeys continue to use the maze with more complex patterns, perhaps the feeding times can begin to approach those seen in the wild.

The opinions and assertions contained herein are the private views of the authors and are not to be construed as official nor do they reflect the views of the Department of tne Army of the Department of Defense. (AR 360-5)

The studies described in this report were reviewed and approved by the Institutional Review Committee/Animal Care and Use Committee at Letterman Army Institute of Research. The manuscript was peer reviewed for compliance prior to submission for publication. In conducting the research described here, the investigators adhered to the "Guide for the Care and Use of Laboratory Animals," DHEW Publication (NIH) 85-23.

REFERENCES

1. Line SW and Houghton P. Influence of an environmental enrichment device on general behavior and appetite in rhesus macaques. Lab Anim Sci 1987; 37(4):508.

2. Line SW. Environmental enrichment for laboratory primates. J Am Vet Med Assoc 1987; 190(7):854-859.

3. Ross PW and Everitt JI. A nylon ball device for primate environmental enrichment. Lab Anim Sci 1988;38(4):481-483.

4. Bryant CE, Rupniak NMJ and Iversen SD. Effects of different environmental enrichment devices on cage stereotypies and autoaggression in captive cynomolgus monkeys. J Med Primatol 1988;17:257-269.

5. Jerome CP and Szostak L. Environmental enrichment for adult, female baboons (*Papio anubis*). Lab Anim Sci 1987;37(4):508.

6. Line SW, Clark AS and Markowitz H. Behavioral and physiologic response of rhesus macaques to an environmental enrichment device. Lab Anim Sci 1987;37(4):509.

7. Schmidt MJ and Markowitz H. Behavioral engineering as an aid in the maintenance of healthy zoo animals. J Am Vet Med Assoc 1977;172(9):966-969.

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